Lecture 06, 07 Sept 2006
Ch4, Leopold, Costanza, Driessen

Conservation Biology
ECOL 406R/506R
University of Arizona
Fall 2006

Kevin Bonine
Kathy Gerst

Biodiversity

Ch4, begin Ch2 for Tues
Lab this Friday (08 Sept 2006), meet S side BSE 1230
(see website for lab readings)

1

Housekeeping, 07 September 2006
Papers to turn in?

Upcoming Readings

today: Leopold, Text Ch.4, Costanza 1997, Driessen 2004

Tues 12 Sept: Textbook Ch. 4, begin Ch 2
Thurs 14 Sept: Text Ch. 2

Short oral presentations
12 Sept Gabe Wigtil and Kim Baker
14 Sept open
19 Sept Tara Luckau and Frank Emmert?
21 Sept Grant Rogers and Jeremy Daniel

2

Grading for Oral Presentations:

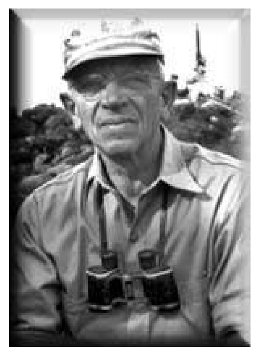
Content
(quality of content, relevance to conservation issues):
25 points

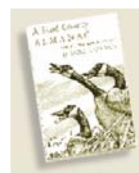
Presentation
(speaking, slide design, professionalism):
10 points

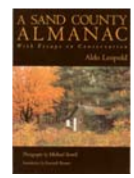
Response to questions:
5 points

3

1887-1948







http://www.aldoleopold.org/Biography/Biography.htm
Aldo Leopold Foundation

4

Leopold

Thinking like a mountain
" a mountain lives in mortal fear of its deer"

Escudilla
progress?
"It's only a mountain now."

The planet will survive, will we?

5

"a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise"

Aldo Leopold

6

Aldo Leopold Land Ethic

-land ethic enlarges the <u>community</u>
to include biota

-processes
-evolutionary/ecological biology

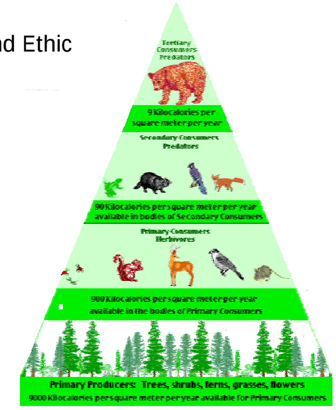
-scale of perturbation (temporal, spatial)

-What is "land-health?"

7

Aldo Leopold Land Ethic

-land pyramid



"In our attempt to make conservation easy we have made it trivial" (p.246)

-Leopold

9

"Whether you will or not

You are a King, Tristram, for you are one

Of the time-tested few that leave the world,

When they are gone, not the same place it was.

Mark what you leave."

As quoted in Leopold, 1949
p. 261 (The Land Ethic)

Role of scale... (context of disturbance and extinction)

Anthropogenic perturbations:

...fast rate and large spatial scale.
(Cited in Callicott 1997)

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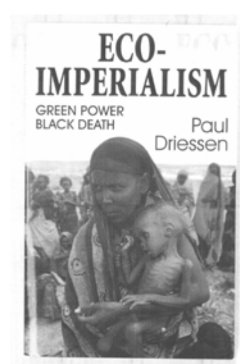

2004 5

Sustainable Mosquitoes – Expendable People

12

Chapter Five Footnotes

1. Fifi Kobusingye, personal conversation with Paul Driessen, May 6, 2003.
2. See www.FightingMalaria.org and extensive studies and articles cited and linked by that website, including "Malaria and the DDT Story," by Dr. Kelvin Kemm of Stratek Technology Strategy Consultants, in *Environment Health* (Lorraine Mooney and Roger Bate, editors). See also Walter Williams, "Killing people," *The Washington Times*, October 17, 2002; Deroy Murdock, "Nutritional Schizophrenia," NationalReviewOnline, June 25, 2002.
3. Barun Mitra and Richard Tren, *The Burden of Malaria*, Delhi, India: Liberty Institute, Occasional Paper 12, November 2002.
4. John Gallup and Jeffrey Sachs, *The Economic Burden of* Malaria, Harvard University Center for International Development, London School for Hygiene and Tropical Medicine, for the World Health Organization, 2000. For a detailed examination of the health, social and economic impacts of malaria – especially on African countries – see Richard Tren and Roger Bate, *When Politics Kills: Malaria and the DDT story*, Sandton, South Africa: Africa Fighting Malaria (2000). A more recent version of *Malaria and the DDT story* can be downloaded from the Institute of Economic Affairs website at http://www.iea.org.uk/record.php?type=publication&ID=11
5. Alexander Gourevitch, "Should the DDT ban be lifted?" *Washington Monthly*, April 9, 2003.
6. The chemical Alar was used to regulate the growth and ripening of apples, until it became the subject of an attack launched by Fenton Communications, the NRDC and CBS's "60 Minutes." In a later interview, David Fenton admitted that "the PR campaign was designed so that revenue would flow back to NRDC from the public." See Bonner Cohen, John Carlisle, *et al.*, *The Fear Profiteers: Do "socially responsible" businesses sow health scares to reap monetary rewards?* Arlington, VA: Lexington Institute (2000).
7. In so doing, Ruckelshaus ignored thousands of pages of scientific evidence attesting to the pesticide's safety and expert recommendations that its use be continued for malaria control.
8. Richard Tren, president, Africa Fighting Malaria, personal communication, December 20, 2002; Brian Sharp, P. van Wyk, et al., "Malaria control by residual insecticide spraying in Chingola and Chililabombwe, Copperbelt Province, Zambia," *Journal of Tropical Medicine and International Health*, pages 732-736, September 2002.
9. Alexander Gourevitch, "Should the DDT ban be lifted?" and Donald Roberts, personal communication to Paul Driessen, April 29, 2003..

10. Richard Tren, "DDT still saving lives," a UPI Outside View commentary, November 11, 2002. See also Bjorn Lomborg, *The Skeptical Environmentalist: Measuring the real state of the world*, Cambridge, UK: Cambridge University Press (2001), pages 233-235, 237, 243-244.
11. See Thomas R. DeGregori, *Bountiful Harvest: Technology, food safety and the environment*, Washington, DC: Cato Institute, 2002, page 132.
12. Fifi Kobusingye, personal conversation with Paul Driessen, May 6, 2003.
13. David Nabarro, director, Roll Back Malaria; quoted in "Malaria Meeting: Africans Discuss a Disease Biting Into Lives and Economies," ABCNews.com, April 2000.
14. Richard Tren, personal communication, December 17, 2002; Roger Bate, "Without DDT, malaria bites back," www.spiked-online.com, April 24, 2001.
15. Richard Tren and Roger Bate, *When Politics Kills: Malaria and the DDT story*, Sandton, South Africa: Africa Fighting Malaria (2000), page 24. All other countries combined contributed only $2.8 million, via the World Health Organization, they note.
16. Personal email to Paul Driessen, April 7, 2003.
17. Richard Tren and Roger Bate, *Malaria and the DDT Story*, London: Institute of Economic Affairs, 2001, page 58.
18. Richard Tren, president, Africa Fighting Malaria, personal communication, December 17, 2002.
19. DeGregori, page 147, citing Matt Crenson, "Thousands of Children Jeopardized by Pesticide Use," Associated Press, Nando.net online, December 18, 1997. Amazingly, the 1996 Food Quality Protection Act specifically forbids the USEPA from considering occupational exposures to pesticides on the part of the children and adults who grow and pick the produce Americans eat.
20. David Kaiza, "Uganda to use DDT despite ban," *The East African*, Nairobi, Kenya, December 2, 2002; Tom Carter, "Kenyan research center favors DDT use: Malaria toll trumps ecological threat," *Washington Times*, May 9, 2003.
21. *New York Times* editorial, December 23, 2002.
22. James Shikwati, "How Europe is killing Africans," *The Day* (New London, CT), February 3, 2003.
23. Niger Innis, "Jesse and Al: Missing in action," Congress of Racial Equality commentary, July 2003.

Costanza et al. 1997

The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farber‖, Monica Grasso†, Bruce Hannon¶, Karin Limburg#, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Sutton‖‖ & Marjan van den Belt¶¶**

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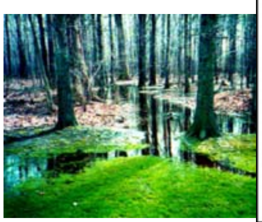
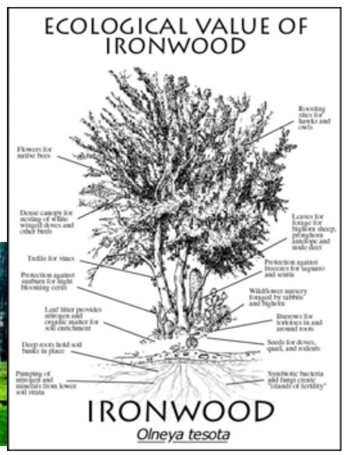
‡ Economics Department (emeritus), University of Wyoming, Laramie, Wyoming 82070, USA
§ Center for Environment and Climate Studies, Wageningen Agricultural University, PO Box 9101, 6700 HB Wageningen, The Netherlands
‖ Graduate School of Public and International Affairs, University of Pittsburgh, Pittsburgh, Pennsylvania 15260, USA
¶ Geography Department and NCSA, University of Illinois, Urbana, Illinois 61801, USA
\# Institute of Ecosystem Studies, Millbrook, New York, USA
** Department of Ecology, Evolution and Behavior, University of Minnesota, St Paul, Minnesota 55108, USA
†† Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA
‡‡ Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av. San Martin 4453, 1417 Buenos Aires, Argentina
§§ Jet Propulsion Laboratory, Pasadena, California 91109, USA
‖‖ National Center for Geographic Information and Analysis, Department of Geography, University of California at Santa Barbara, Santa Barbara, California 93106, USA
¶¶ Ecological Economics Research and Applications Inc., PO Box 1589, Solomons, Maryland 20688, USA

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

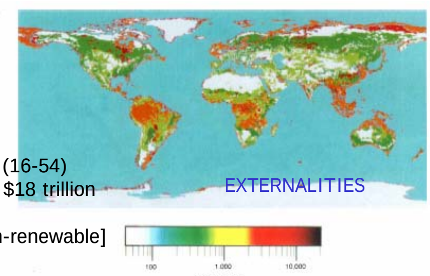
Lesser long-nosed bat (*Leptonycteris curasoae*) pollinating saguaro flower (*Carnegia gigantea*)





Costanza et al. 1997

Figure 2 Global map of the value of ecosystem services. See Supplementary Information and Table 2 for details.



$33 trillion/yr (16-54)
Global GNP = $18 trillion

EXTERNALITIES

[excluded non-renewable]

Gas regulation $1.3 trillion
Disturbance reg. $1.8 trillion
Waste treatment $2.3 trillion
Nutrient cycling $17 trillion

Marine Services $20.9 trillion
(coastal $10.6 trillion)
Forests $4.7 trillion
Wetlands $4.9 trillion

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Costanza et al. 1997
Table 1

Table 1 Ecosystem services and functions used in this study

Number	Ecosystem service*	Ecosystem functions	Examples
1	Gas regulation	Regulation of atmospheric chemical composition.	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels.
2	Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels.	Greenhouse gas regulation, DMS production affecting cloud formation.
3	Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations.	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure.
4	Water regulation	Regulation of hydrological flows.	Provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation.
5	Water supply	Storage and retention of water.	Provisioning of water by watersheds, reservoirs and aquifers.
6	Erosion control and sediment retention	Retention of soil within an ecosystem.	Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands.
7	Soil formation	Soil formation processes.	Weathering of rock and the accumulation of organic material.
8	Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients.	Nitrogen fixation, N, P and other elemental or nutrient cycles.
9	Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment, pollution control, detoxification.
10	Pollination	Movement of floral gametes.	Provisioning of pollinators for the reproduction of plant populations.
11	Biological control	Trophic-dynamic regulations of populations.	Keystone predator control of prey species, reduction of herbivory by top predators.
12	Refugia	Habitat for resident and transient populations.	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds.
13	Food production	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing.
14	Raw materials	That portion of gross primary production extractable as raw materials.	The production of lumber, fuel or fodder.
15	Genetic resources	Sources of unique biological materials and products.	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants).
16	Recreation	Providing opportunities for recreational activities.	Eco-tourism, sport fishing, and other outdoor recreational activities.
17	Cultural	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.

* We include ecosystem 'goods' along with ecosystem services.

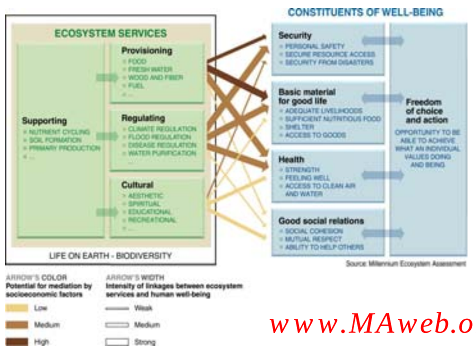
Table 2 Summary of average global value of annual ecosystem services

[illegible]

Costanza et al. 1997 Table 2

Focus: Consequences of Ecosystem Change for Human Well-being

Millenium Ecosystem Assessment



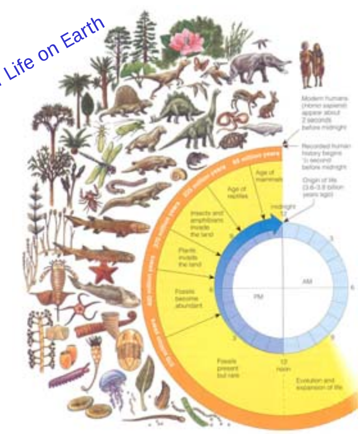
www.MAweb.org

2) Should 'intrinsic' or 'instrumental' values be the basis for planning conservation efforts? Why? (due 07 Sep)

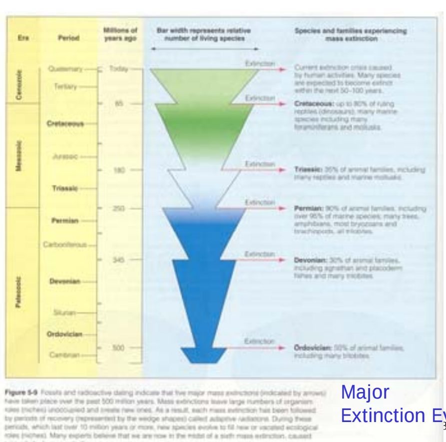
Nothing in biology makes sense except in the light of evolution.

THEODOSIUS DOBZHANSKY

Evolution of Life on Earth



Miller 2003



Miller 2003

Major Extinction Events

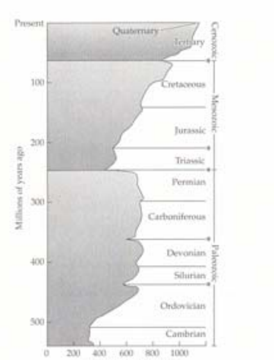


Figure 2.5 Diversity of marine families from the Cambrian to the present. The asterisks mark the five major mass extinction events.

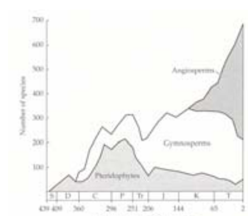


Figure 2.6 Terrestrial plant species richness. Ferns, gymnosperms, and angiosperms have, in turn, dominated the world's flora. (Modified from Signor 1990.)

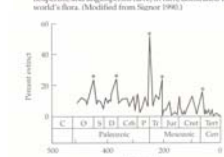


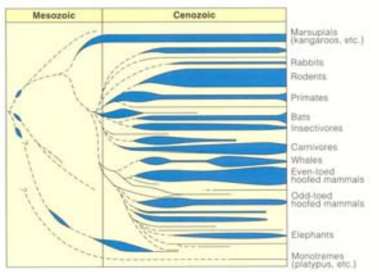
Figure 2.7 Extinctions of families through geologic time. The five historical mass extinction events are marked with an asterisk.

Groom et al. 2006

Adaptive Radiation

Figure 5-10 Adaptive radiation of mammals began in the first 10–12 million years of the Cenozoic era (which began about 65 million years ago) and continues today. This evolution of a large number of new species is thought to have resulted when huge numbers of new and vacated ecological niches became available after the mass extinction of dinosaurs near the end of the Mesozoic era. (Used by permission from Cecie Starr and Ralph Taggart, *Biology: The Unity and Diversity of Life*, 8th ed., Belmont, Calif.: Wadsworth, 1998)

Miller 2003



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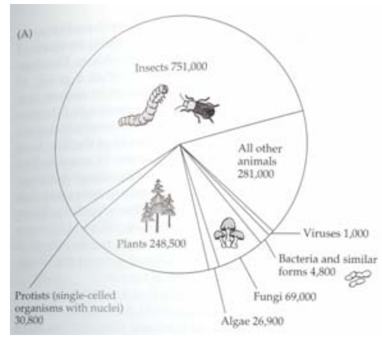
What is biodiversity?



Primack 2006, Fig 3.6

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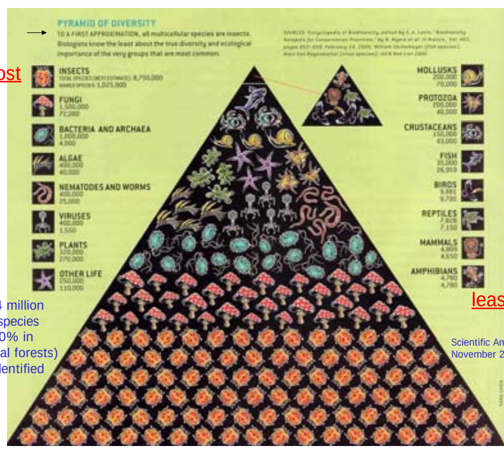
most

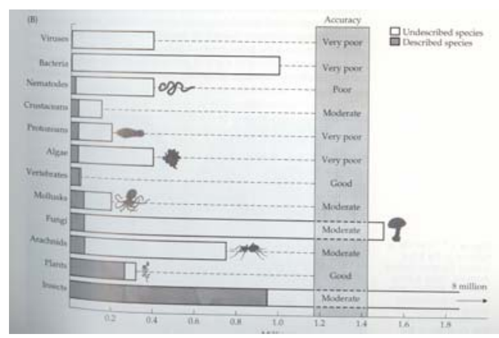


least

~12-14 million total species (50-90% in tropical forests)
~1.7 identified

Scientific American November 2001

How many species on earth?



Primack 2006, Fig 3.6

Research Focus?

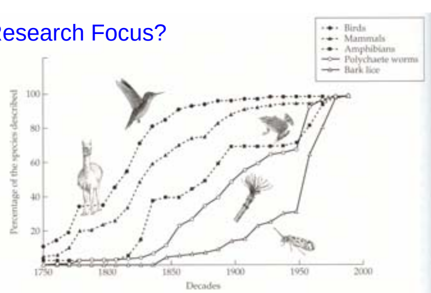


FIGURE 3.10 For five groups of Chilean animals, the cumulative percentage of the known species described from 1750 to 2000. Note that the majority of birds and mammals were largely described by 1900, and probably few new species remain to be discovered. In contrast, polychaete worms and bark lice were largely neglected by early taxonomists and are only now being investigated and described. Amphibians are intermediate in their intensity of study. (After Primack et al. 2001.)

Primack 2006

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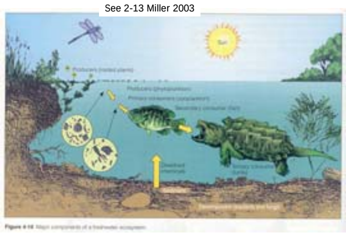
See 2-13 Miller 2003



Biodiversity

1. Genetic
(nat. sel.)

2. Species

3. Ecological
forests, deserts, lakes, wetlands, reefs etc.

4. Functional
energy flow
nutrient cycling
etc.

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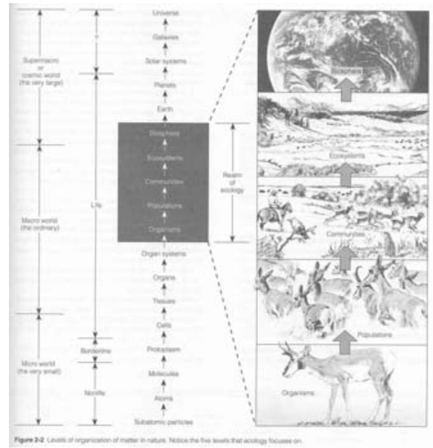
Levels of Biological Organization.

Scaling.

Miller, 2003



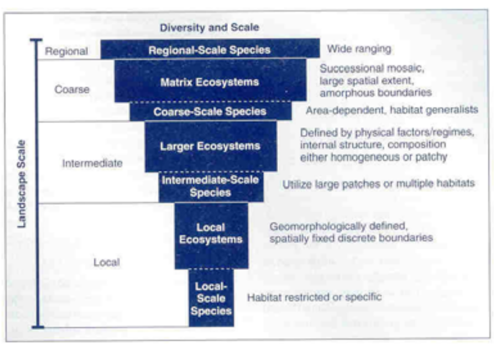


Figure 4.15 Van Dyke 2003
Biodiversity and scale. A method of categorizing biodiversity at regional, coarse, intermediate, and local geographic scales.
Modified from Poiani et al. (2000). © 2001 American Institute of Biological Sciences.

Groom et al. 2006

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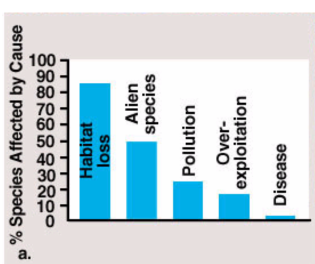
Threats to biodiversity – habitat loss



Thanks to Chuck Price

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Biodiversity (Biological Diversity)
"structural and functional variety of life forms at genetic, population, community, and ecosystem levels"

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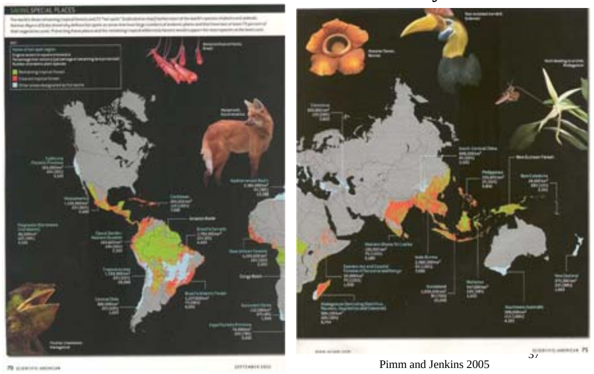
Where is biodiversity?

One tree in Peru with same ant diversity as Britain



Pimm and Jenkins 2005

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Species Richness and Latitude

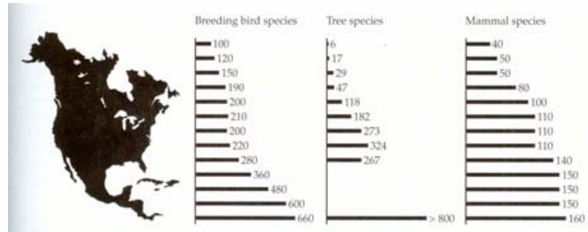

FIGURE 3.5 In North America, as in all the continents, the numbers of bird, tree, and mammal species increase toward the Tropics. The numbers of species indicated in the bar graphs correspond to latitude in the map at left. Tree species diversity is not available for some lower latitudes. (From Briggs 1995.)

Altitude?

Primack 2006

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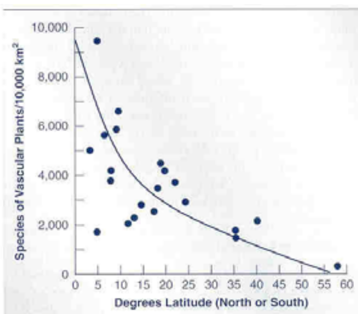

Figure 4.12

Latitudinal patterns in species richness from tropical to temperate regions. In most taxa the number of species increases from temperate to tropical regions.

Van Dyke 2003

After Reid and Miller (1989). Reprinted from Huston (1994).

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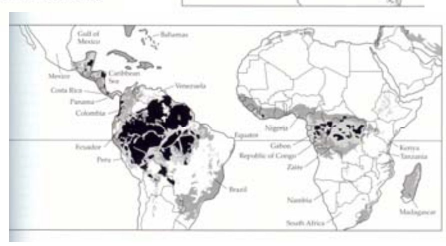
FIGURE 3.1 Tropical rain forests are found predominantly in wet, equatorial regions of America, Africa, and Asia. Eight thousand years ago, tropical forests covered the entire shaded area, but human activities have resulted in the loss of a great deal of forest cover, shown in the darkest shade. In the lighter shaded area forests remain, but they are no longer true tropical forests; instead they are (1) secondary forests that have grown back following cutting, (2) plantation forests such as rubber and teak, or (3) forests degraded by logging and fuelwood collection. Only in the regions shown in black are there still blocks of intact natural tropical forest large enough to support all of their biodiversity. (After Bryant et al. 1997.)

Tropical Rainforests



Primack 2006

Coral Reefs

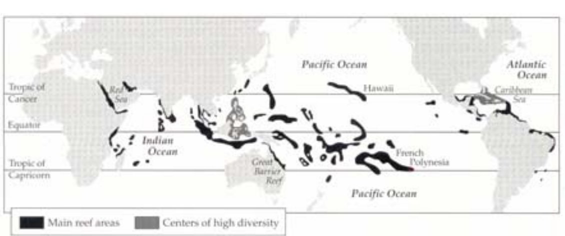


FIGURE 3.4 Global distribution of the coral reef biome. (After Wells and Hanna 1992.)

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Primack 2006

Lissamphibia

Urodela (salamanders)

10 families, 60 genera, 516 spp.

Ambystoma tigrinum

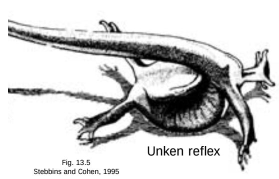


Fig. 13.5
Stebbins and Cohen, 1995

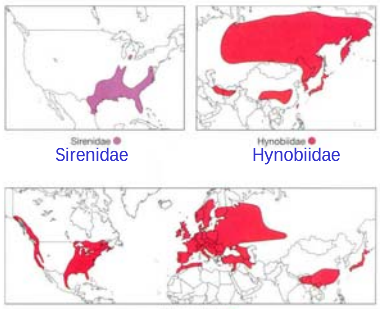
Ambystoma californiense

Urodela families

Figure 3–3 Distribution of salamander families Sirenidae, Hynobiidae, and Salamandridae.

Pough et al. 2004

(only 1 of 10 not found in U.S.)



Urodela families

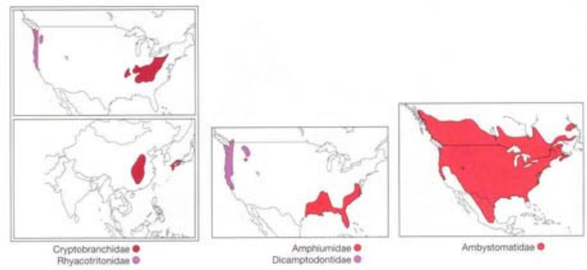


Figure 3–4 Distribution of salamander families Cryptobranchidae, Rhyacotritonidae, Amphiumidae, Dicamptodontidae, and Ambystomatidae.

Pough et al. 2004

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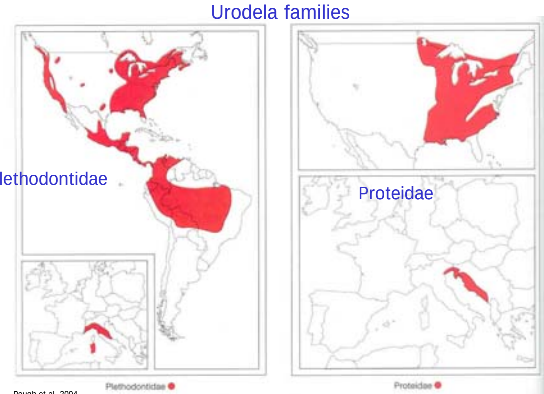
Urodela families



Pough et al. 2004

Figure 3–7 Distribution of the salamander families Plethodontidae and Proteidae.

What factors correlated with high diversity?

- Energy
- Precipitation
- Temperature
- Area
- Habitat heterogeneity (e.g., foliage height and birds)
- Stable environment
- Moderate (intermediate) disturbance level
  (shifting mosaic, no climax)

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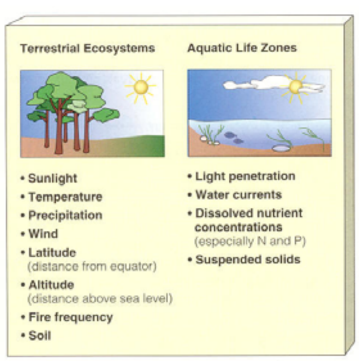
Distribution and Abundance



Other Miller 2003

Figure 4-12 Key physical and chemical or abiotic factors affecting terrestrial ecosystems (left) and aquatic life zones (right).

Distribution and Abundance

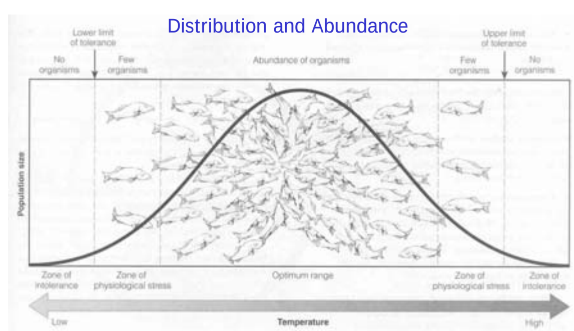


Figure 2-16 Range of tolerance for a population of organisms to an abiotic environmental factor—in this case, temperature.

Miller, 2003

Range of tolerance of abiotic factor(s)

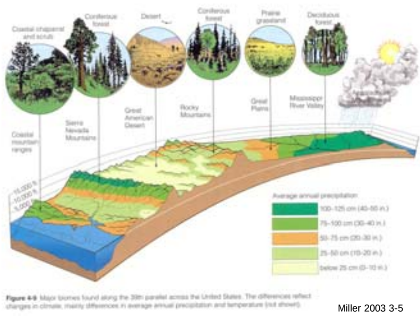
48

Terrestrial Biomes

(Forest, Desert, Grassland, Tundra, etc.)
Biotic (~Vegetative) Communities

Climate
1. Temperature
2. Precipitation
(3. Soil type)

- Latitude
- Altitude



Miller 2003 3-5

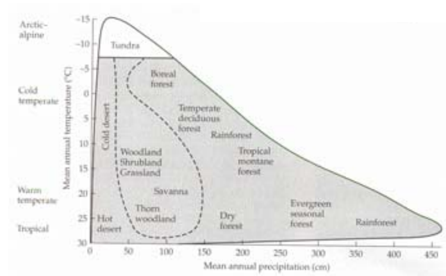


Figure 2.4 Biomes and climate. Distributions of the major biomes are plotted on axes of mean annual precipitation. Within the region bounded by the dashed line, factors such as seasonality of drought, fire, and grazing strongly affect which type of vegetation is present (Modified from Whittaker 1970.)

Groom et al. 2006

1. Competition

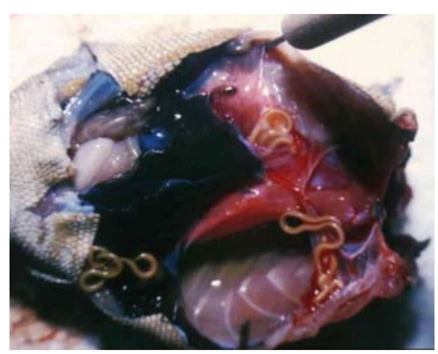
Anolis

Ecomorphs on Caribbean Islands

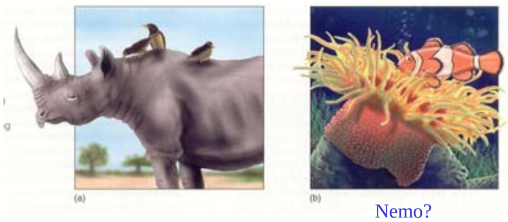
Pisaster (predatory sea star)
Paine
15 vs. 8 spp.
(mussels)

2. Predation

3. Parasitism



4. Mutualism



Nemo?

See 4-2 in Miller 2003

55

5. Commensalism

Florida

Ecuador

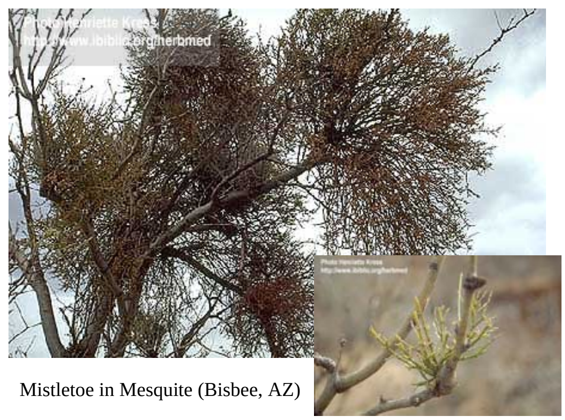
Bromeliads

56

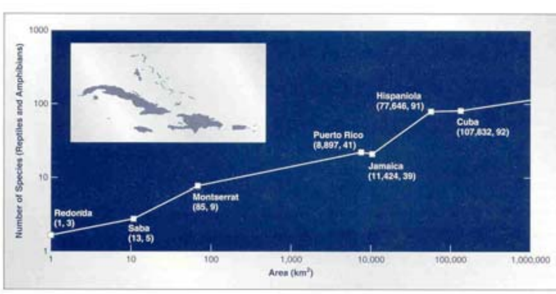
Stalk-Eyed Flies

Sexual Selection

57



Mistletoe in Mesquite (Bisbee, AZ)



Van Dyke 2003

Figure 4.4
A general species-area relationship among some Caribbean islands. Note that species richness on islands increases with increasing area.
Based on data from Darlington (1957:483).

Species-Area Relationship

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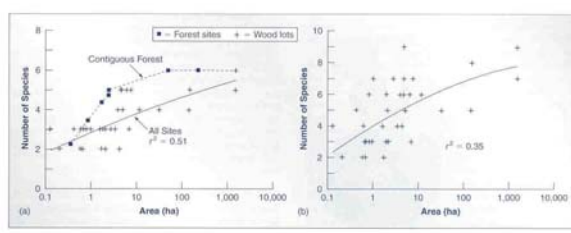

Figure 4.5
An illustration of the relationship between area and species richness of (a) granivores and (b) all small mammal species in woodlots (crosses) and contiguous forest sites (squares). Species richness increases with woodlot area. In (a), note that granivore species richness increases with area more rapidly in contiguous forest than in woodlots. This pattern suggests that species richness not only declines with habitat loss, but also with habitat fragmentation.
After Nupp and Swihart (2000).

Van Dyke 2003

Woodlots vs. contiguous forest

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Species-Area Relationship

$S = cA^Z$

S = species richness
c = taxon-specific constant
A = area
Z = extinction coefficient for taxon

3 step loss of biodiversity
(Rosenzweig)

1. Endemics
2. Sink populations
3. Stochasticity

Therefore end up with lower steady state species richness and loss of biodiversity

Endemism and Islands (Tuatura, Silversword)
Island Biogeography

3 step loss of biodiversity
(Rosenzweig)

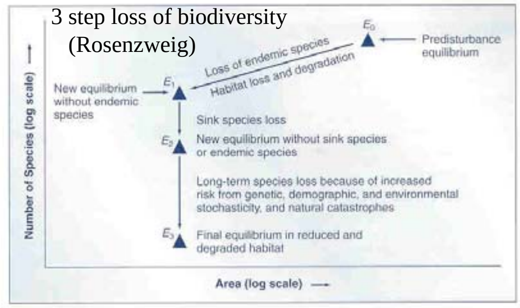

Figure 4.6
When the size of a natural area is decreased, the first species lost are endemics. Next, sink species (those that are not reproducing fast enough to replace themselves) go extinct locally. Finally, failure to replace accidental losses fast enough brings the province to a still lower steady state of biodiversity.
After Rosenzweig (1999).

Van Dyke 2003

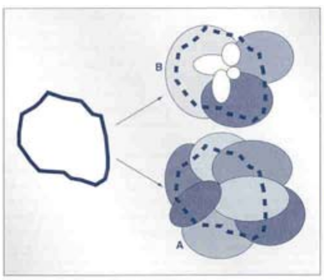

Figure 4.7
The "cookie cutter" model of the effects of habitat loss on endemic species. If the cookie cutter strikes at subarea A, seven species lose habitat but none is exterminated. In contrast, if the cookie cutter strikes subarea B, an area containing species with more restricted ranges, seven species lose habitat, and four species are exterminated. Thus, random habitat loss produces a disproportionately high rate of extinction in endemic species.
After Pimm (1998).

Van Dyke 2003

Endemics
Habitat Size
Habitat Loss

63

Species Focus ---> Biodiversity and Process Focus
(ESA)

What being lost vs. why…

64

Species = ?

Biological Species Concept (Mayr)
"a group of interbreeding populations that are reproductively isolated from other such groups"

2-morphological/typological species concept (plants)
3-evolutionary species concept
4-genetic species concept
5-paleontological species concept
6-cladistic species concept

65

Biological Species Concept
1. Testable and operational
2. Definition compatible with established legal concepts
3. Focus on level of biodiversity that agrees with tradition of conservation

Conserve Species as
TYPES
or as
EVOLUTONARY UNITS

66

Ernst Mayr is one of the greatest influences on evolutionary biology since Darwin. Mayr was one of the architects of the evolutionary synthesis of the 1930s and 1940s, which unified biology by integrating Darwin's theory of natural selection with new discoveries in genetics, paleontology, and taxonomy. Mayr based his views on evolution mainly on relationships among bird species that he studied on Pacific islands. Now 89 years old, Mayr, Professor Emeritus at Harvard, is still going strong and generating exciting new ideas. His latest book, One Long Argument *(Harvard University Press, 1991), analyzes Darwin's theories. I interviewed Professor Mayr at his summer cottage in New Hampshire.*

Campbell 1993

Ernst Mayr (1904-2005)
Published papers for > 80 years

67

Figure 22.3
Ernst Mayr in New Guinea, 1927. During his expedition, the naturalist (on the right, photographed with his guide) was struck by the almost exact match in how he and the native Papuans divided the birds of the Arafak Mountains into separate species. It was one of many experiences that led to Mayr's biological species concept, which emphasizes interbreeding within species and reproductive isolation between species.

You've also written that we humans have extraordinary responsibility because of our uniqueness as a species.
Yes, humans are basically responsible for all the bad things that at the present time happen to our planet, and we are the only ones who can see all these things and do something about them. If we would stop the human population explosion, we would have already won two-thirds of the battle. That we live here just as exploiters of this planet is an ethic that does not appeal to me. Having become the dominant species on our planet, we have the responsibility to preserve the well-being of this planet. I feel that it should be a part of our ethical system that we should preserve and maintain and protect this planet that gave origin to us.

Ernst Mayr interviewed in Campbell 1993

Galapagos Finches

Brassica oleracea

Figure 17-8 A number of common vegetables are members of the same species, *Brassica oleracea*, including cauliflower, broccoli, cabbage, brussels sprouts, and kale. Artificial selection is responsible for the variation shown within this species. (Raymond Tschoepe)

Solomon et al. 1993

69

Aspidoscelis (*Cnemidophorus*)
Species vs. Parthenospecies...

70

1. Indicator Species
   - -migratory birds
   - -amphibians

2. Keystone Species
   - -top predators
   - -key pollinators

Rana pipiens
Northern Leopard Frog

3. Umbrella Species

Native Species
vs.
Nonnative, exotic, alien

71

Measuring Biodiversity
- alpha - beta - gamma

Alpha
species within a community

community
- all populations occupying a given area at a given time
- often broken into taxonomic groups or functional roles

1) Species Richness (# of species)
2) Species Evenness (how many of each type?)

Shannon Diversity Index (richness and evenness)

$H' = -\sum_i p_i \ln (p_i)$, ($i$ = 1, 2, 3 ... S)

p_i = proportion of total community abundance represented by ith species

72

Table 4.3 Abundance (individuals/10 ha) and diversity (Shannon index, $H' = -\Sigma(p_i \ln p_i)$) of avian species from two tallgrass prairie sites at DeSoto National Wildlife Refuge, Iowa. Note that site A, with fewer species (8) and two highly abundant species (common yellowthroat and field sparrow), has a lower value of diversity than site B, which has more species (11) that are more equally abundant. Van Dyke 2003

SPECIES	SITE A	SITE B
Common yellowthroat	8.24	1.21
Field sparrow	2.94	2.84
Dickcissel	1.18	2.23
Red-winged blackbird	0.29	0.81
Brown-headed cowbird	2.06	1.82
American goldfinch	1.47	1.02
Ringneck pheasant	0.59	1.63
Mourning dove	1.18	0.61
Eastern kingbird	—	1.60
Grasshopper sparrow	—	4.48
Northern bobwhite	—	2.64
Shannon diversity (H')	1.64	2.25

Shannon Index in Tallgrass Prairie

(indiv spp abundance relative to total abundance)

What if removed three species from B?

1.64					2.25			
a	prop	ln	propxln		b	prop	ln	propxln
8.24	0.459053	-0.77859	-0.35741		1.21	0.057922	-2.84865	-0.165
2.94	0.163788	-1.80918	-0.29632		2.84	0.13595	-1.99547	-0.27128
1.18	0.065738	-2.72208	-0.17894		2.23	0.10675	-2.23727	-0.23883
0.29	0.016156	-4.12546	-0.06665		0.81	0.038775	-3.24999	-0.12602
2.06	0.114763	-2.16488	-0.24845		1.82	0.087123	-2.44043	-0.21262
1.47	0.081894	-2.50233	-0.20493		1.02	0.048827	-3.01947	-0.14743
0.59	0.032869	-3.41522	-0.11226		1.63	0.078028	-2.55069	-0.19902
1.18	0.065738	-2.72208	-0.17894		0.61	0.029201	-3.53357	-0.10318
					1.6	0.076592	-2.56927	-0.19678
					4.48	0.214457	-1.53965	-0.33019
					2.64	0.126376	-2.06849	-0.26141
17.95	1		**-1.64391**		20.89	1		**-2.25177**
drop top 3					drop bottom 3			
b	prop	ln	propxln		b	prop	ln	propxln
					1.21	0.099425	-2.30835	-0.22951
					2.84	0.233361	-1.45517	-0.33958
					2.23	0.183237	-1.69697	-0.31095
0.81	0.055441	-2.89243	-0.16036		0.81	0.066557	-2.70969	-0.18035
1.82	0.124572	-2.08287	-0.25947		1.82	0.149548	-1.90014	-0.28416
1.02	0.069815	-2.6619	-0.18584		1.02	0.083813	-2.47917	-0.20779
1.63	0.111567	-2.19313	-0.24468		1.63	0.133936	-2.01039	-0.26926
0.61	0.041752	-3.176	-0.13261		0.61	0.050123	-2.99327	-0.15003
1.6	0.109514	-2.2117	-0.24221					
4.48	0.306639	-1.18208	-0.36247					
2.64	0.180698	-1.71093	-0.30916					
14.61	1		**-1.8968**		12.17	1		**-1.97163**

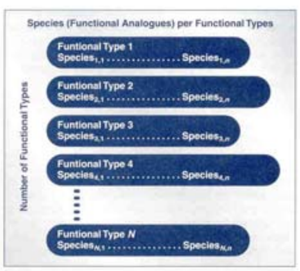

Figure 4.3
Total species diversity can be measured as the product of the number of functional types and the number of species per functional type. Two populations may have the same species diversity and still differ. For example, one may have many functional types and few functional analogues, and the other may have many analogues but few functional types. The relative number of functionally analogous species within each functional type is indicated by the width of the oval. Van Dyke 2003

Process and Pattern

1 Functional Types
2 Functional Analogs

Increase either to increase biodiversity

Which to preserve?

Niche:
Ecological role of a species in a community

Measuring Biodiversity
- alpha - beta - gamma

Beta
area or regional diversity (beta richness)
diversity of species among communities across landscape

gradient
- slope, moisture, temperature, precipitation, disturbance, etc.

Whittaker's Measure = (S/alpha) - 1

where S = # spp in all sites, alpha = avg. # spp/site

a) if no community structure across gradient = 0
-broad ecological tolerances, niche breadth

b) 100/10 - 1 = 9 high beta diversity

Beta Diversity

1) quantitative measure of diversity of communities that experience changing environmental gradients

2) are species sensitive, or not, to changing environments?
are there associations of species that are interdependent
(plants, pollinators, parasites, parasitoids)?

3) how are species gained or lost across a TIME gradient?

Succession, community composition, effects of disturbance

Alpha and Beta Diversity Hotspots

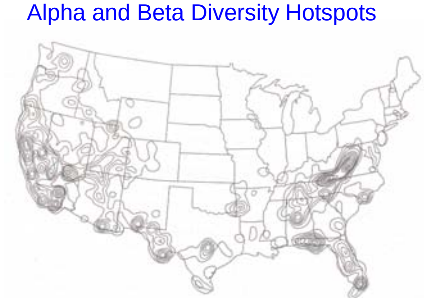

Figure A Hot spots of rarity and species richness in the lower 48 United States. Read as a topographic map with concentric circles showing higher values of the rarity-weighted species richness index (RWRI). Hotspots are found in CA, the Death Valley region of Nevada, the Appalachian Mountains, and the Florida panhandle and Everglades. Many other regions of higher diversity are found in other parts of the U.S., and the Hawaiian islands (not shown) have the greatest concentration of range-restricted species by far. To achieve a high RWRI both α- and β-diversity must be high. (Modified from Stein et al. 2000.)

Groom et al. 2006

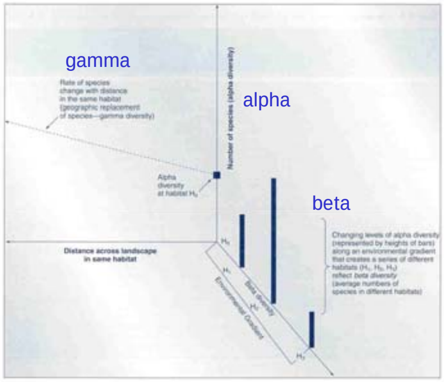

Figure 4.2

Van Dyke 2003

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Measuring Biodiversity
- alpha - beta - gamma

Gamma

rate of change of species composition with distance (geography, rate of gain and loss of species)

alpha rarity with increased number of species
(fewer of each type)

beta rarity with habitat specialists

gamma rarity if restricted to particular geographic areas

80

Measuring Biodiversity
- alpha - beta - gamma

Missing?

Species role in ecosystem?
Rarity
Phylogenetic Representation
Ecological Redundancy

Edges vs. Interior (e.g., fragmentation)
(spp richness increases, but are broad generalists, not interior habitat specialists)

All species are not equivalent (normative valuation?)

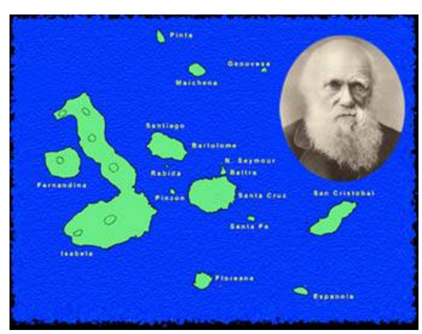
81

Endemism...

82

http://www.rit.edu/~rhrsbi/GalapagosPages/DarwinFinch.html

83



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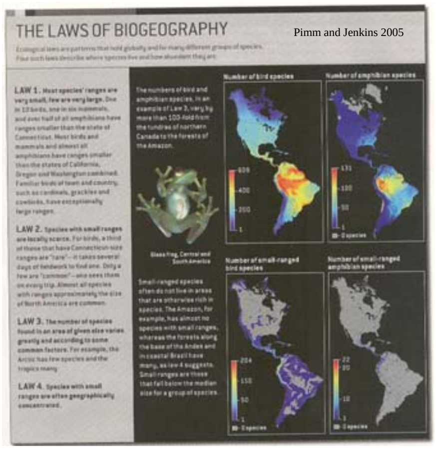

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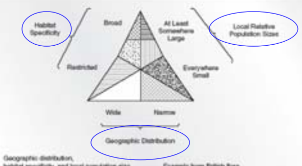

Symbol	Geographic distribution, habitat specificity, and local population size	Example from British flora
	Wide, broad, at least somewhere large	*Deschampsia caespitosa*, tufted hair-grass
	Wide, broad, everywhere small	*Hypochoeris maculata*, spotted gosmore
	Wide, restricted, at least somewhere large	*Ammophila arenaria*, marram grass
	Wide, restricted, everywhere small	*Draba muralis*, wall whitlow grass
	Narrow, broad, at least somewhere large	*Primula scotica*, Scottish bird's-eye primrose
	Narrow, restricted, at least somewhere large	*Agrostis setacea*, bristle-leaved bent
	Narrow, broad, everywhere small	(no example)
	Narrow, restricted, everywhere small	*Lloydia serotina*, alpine lily

Figure 4.9
Eight categories of species abundance in British plants based on geographic range, habitat use, and relative population size. Note that only one category (broad habitat specificity, wide geographic distribution, and large local populations) can truly be considered "common." Species in the other seven categories are rare in one or more dimensions.

Adapted from Rabinowitz, Cairns, and Dillon (1986).

VanDyke 2003

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Cyprinodon macularius

Desert Pupfish

Photograph Courtesy of John Rinne

Desert pupfish declined due to the introduction and spread of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, groundwater pumping, stream channelization, and habitat modification.

Healthy population of almost 10,000 fish inhabits this oasis. This last refuge of a unique fish is being actively managed.

Cyprinodon macularius

Desert Pupfish

Family Cyprinodontidae

Photograph Courtesy of John Rinne

-1-1/4 inches long
max. age of three years

-females are gray and drab
males are bluish, turning bright blue during spring breeding season.

-feed on insect larvae and other organic matter from pond bottom.

-prefer shallow pond depths, about 12 to 18 inches deep.

Quitobaquito pupfish (Endangered since 1986)

This tiny fish was once part of a widespread population, the range of which included the Colorado, Gila, San Pedro, Salt and Santa Cruz rivers and their tributaries in Arizona and California. The ancestors of the Quitobaquito and Sonoyta river pupfish are believed to have been cut off from their relatives in the Colorado River drainage about one million years ago.

The warm, slightly brackish water at Quitobaquito is ideal habitat for pupfish. Pupfish can tolerate salinity levels ranging from normal tap water to water three times saltier than the ocean. Therefore, they are well suited to desert environments where high evaporation rates create water with high salinity levels.

Although the water temperature at the spring is a constant 74°F, the water temperature in the pond fluctuates greatly during the year, from about 40°F or cooler in January to almost 100°F in August, especially in shallow areas... very tolerant of rapid temperature change and low oxygen content due to summer heat.

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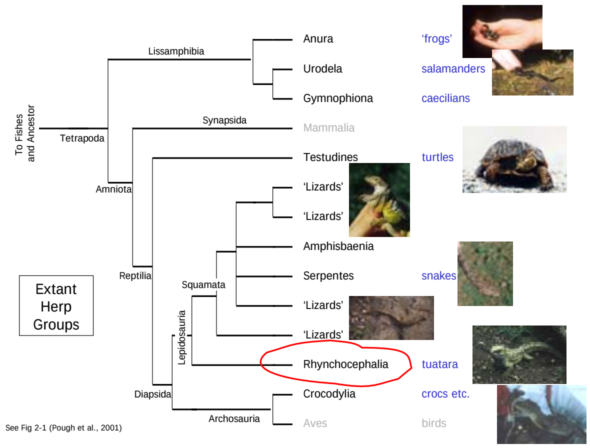
Pricing Biodiversity

$R_I = (D_i + U_i)(\text{delta}P_i/C_i)$

D = distinctiveness
U = utility
delta P = enhanced probability of survival
C = cost of strategy

Direct limited funds...
Ecological Contribution?

90



Rhynchocephalia

- evolved before dinosaurs
- world-wide distribution in Mesozoic
- most extinct at end Cretaceous (65mya)

Sphenodontidae
- 1 extant genus (*Sphenodon*)
- 2 extant species
- restricted to small islands of New Zealand
- long lived

Pricing Biodiversity

$R_I = (D_i + U_i)(\text{delta}P_i/C_i)$

D = distinctiveness
U = utility
delta P = enhanced probability of survival
C = cost of strategy

Direct limited funds...
Ecological Contribution?

Discussion:

Biodiversity vs. Wilderness

"no essential contradiction between social interests and biodiversity conservation"

p.109, VanDyke (Sarkar, 1999)

END